An efficient preconditioner for large-displacement fluid-structure interaction problems

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This paper is concerned with the fully-coupled ('monolithic') solution of large-displacement fluid-structure interaction problems by Newton's method. We show that block-triangular approximations of the Jacobian matrix, obtained by neglecting selected fluid-structure interaction blocks, provide good preconditioners for the solution of the linear systems with GMRES. We present an efficient approximate implementation of the preconditioners, based on Elman's [1] pressure Schur complement approximation for the Navier-Stokes block, and the use of multigrid approximations for the solution of the computationally most expensive operations. The performance of the preconditioners is examined in representative steady and unsteady simulations of the two-dimensional model problem illustrated in Fig. 1. The studies show that the GMRES iteration counts only display a mild dependence on the Reynolds number and the mesh size. Finally, we demonstrate the importance of consistent stabilisation for the accurate simulation of fluid-structure interaction problems.

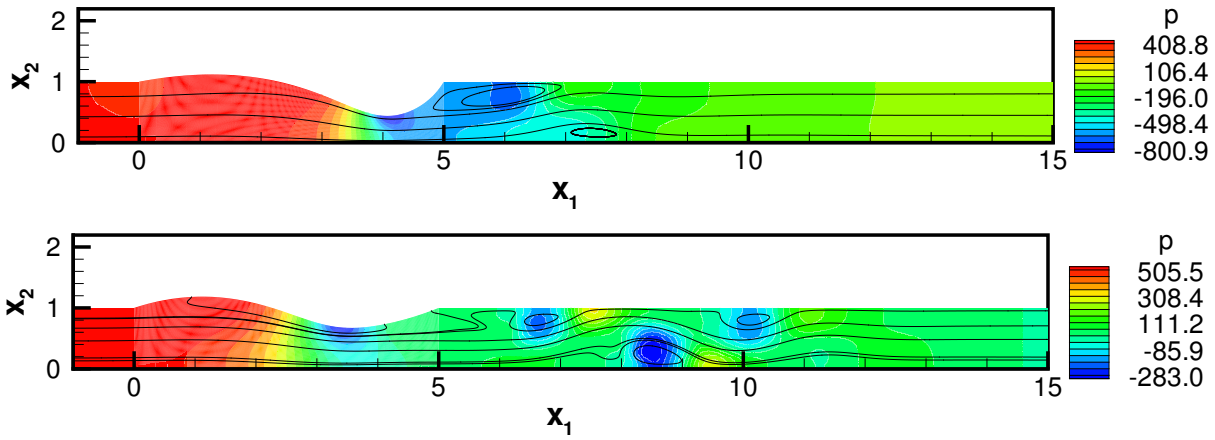

Figure 1: Test case for the evaluation of the preconditioner in unsteady problems: Finite Reynolds number flow ($Re = 500$) through a 2D channel with an elastic wall (located between $x_1 = 0$ and $x_1 = 5$). The system performs large-amplitude self-excited oscillations.

References

[1] H. Elman, "Preconditioning the steady-state Navier-Stokes equations with low viscosity," *SIAM Journal of Scientific Computing* , v. 29, p. 1299-1316, 1999.